(12) UK Patent Application (19) GB (11) 2 140 117 A

(43) Application published 21 Nov 1984

(21) Application No 8411559

(22) Date of filing 4 May 1984

(30) Priority data
(31) 8313646 (32) 17 May 1983 (33) GB

(51) INT CL^3
F16L 15/00

(52) Domestic classification
F2G 25A
U1S 1884 F2G

(56) Documents cited
None

(58) Field of search
F2G
F2H

(71) Applicant
BOC-Nowsco Limited (United Kingdom),
Hammersmith House, Hammersmith, London W5 9DX

(72) Inventor
Roderick Leonard Shulver

(74) Agent and/or Address for Service
Mathisen Macara & Co,
Lyon House, Lyon Road, Harrow, Middlesex HA1 2ET

(54) Screw-thread protection

(57) A dry lubricant such as molybdenum disulphide is applied to one threw thread and sealing surface, and a liquid lubricant eg aqueous wetting agents is applied to the other screw thread and sealing surface to protect mating screw threads eg in oil and gas pipelines. The screw threads are then tightened to the required torque value.

GB 2 140 117 A

2140117

1/1

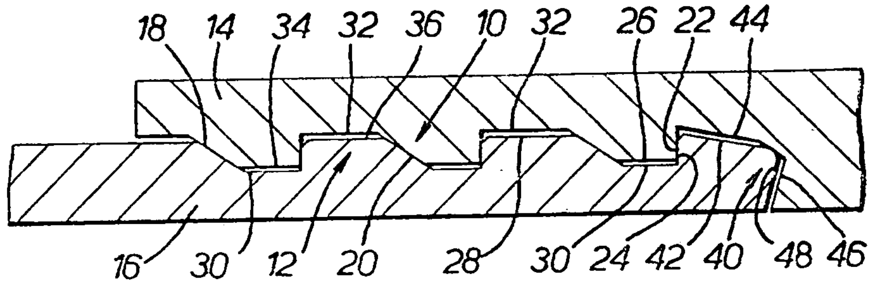

FIG. 1.

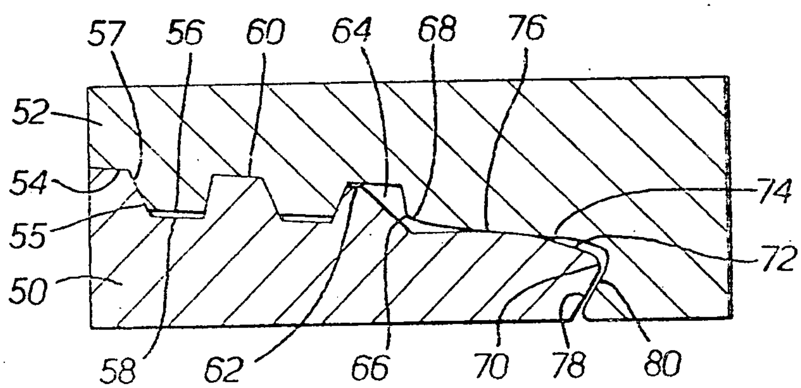

FIG. 2.

SPECIFICATION

Screw-thread protection

This invention relates to screw-thread protection.

It is conventional practice in tubing (pipeline) couplings to make use of a dope or sealant applied to mating screw threads with the intention of lubricating the threads and minimizing the risk of leakage. Such dopes may give rise to no difficulty in use when the internal pressure in the pipeline is low and the ambient temperature is modest (i.e. room temperature) but substantially greater difficulty may be encountered where high pressures and temperatures are involved such as, for example, in production and reinjection tubing strings for oil and gas wells.

The problems of high pressures in gas and oil wells have resulted in the development of lubricants (or dopes) with a hydrocarbon grease base and with the addition of comparatively large particles (of the order of 100 microns) of copper, graphite, zinc, lead or other materials or mixtures thereof. These will tend to accumulate in the root helices of the mating screw threads and in theory these particles will prevent the establishment of helical leakage paths. However, the effect of high temperatures results in a lowering of the viscosity of the grease base and in conjunction with the high pressure allows a leakage path to be established between the comparatively large particles. The leakage path along the screw-thread would have no serious consequence provided that the especially provided sealing surfaces were themselves fully engaged and thus effective, but there is a possible risk that the sealing surfaces themselves are not in practice fully effective if the tightening torque has not fully flattened the coarse particles lying on the shoulder or other final abutment of the two mating threads. There is also a risk that the sealing faces themselves may be damaged by the coarse particles.

Tests have been applied to tubing strings (pipelines) prior to installation to detect any existing leaks, but the dopes hitherto used have masked the leaks which only become apparent when the tubing is in use. Thus, conventional and previously proposed dopes which ostensibly prevent leakage in damaged or defective couplings, in practice merely mask the leaks until the tubing is run in the well at which time it is difficult and expensive to remedy the leaks.

It would therefore be desirable, when testing tubing connections for leak tightness, to avoid the use of dopes with coarse particles and a viscous carrier which can temporarily prevent a leakage flow passing through.

According to the present invention there is provided a method of protecting mating screw threads and associated sealing surfaces at least under tightening torques, the method comprising the steps of applying a dry film lubricant to one screw thread and the associated sealing surface, applying a liquid lubricant to the other screw thread and the associated sealing surface, mating the screw threads and tightening to the required torque value, the liquid lubricant having substantially no solvent action on the dry film lubricant, the method serving both to protect both mating threads and associated sealing surfaces and to avoid the masking of any leakage path between the threads.

Further according to the present invention there is provided a method of protecting the screw threads and associated sealing surfaces of mating screw-threaded members at least under tightening torques, the method comprising the steps of spraying a dry film lubricant in a volatile carrier on to a female thread and associated sealing surface, allowing the carrier to evaporate, applying a liquid lubricant to the male thread and associated sealing surface, immediately mating the threads and tightening to the required torque value, the liquid lubricant having good wetability and low viscosity, the method serving to protect the threads and sealing surfaces against mutual damage and to prevent masking of any leakage path under test conditions.

The invention will now be described, by way of example, with reference to the accompanying diagrammatic drawing in which:

Figure 1 is a fragmentary, longitudinal, section of a conventional screw-threaded parts assembly such as incorporated, for example, in oil and gas well tubing strings; and

Figure 2 is a fragmentary, longitudinal, section of another conventional screw-threaded parts assembly, similar to that of Fig. 1, and referred to as a casing string.

Referring now to the drawing, the screw-threaded parts are shown with clearances exaggerated for the sake of clarity. Such parts have thread forms known generally as buttress threads and are used extensively in tubing coupling arrangements for the oil and gas well industries, for example tubing strings and casings.

The screw threads 10, 12 of the parts 14, 16 of the assembly each have inclined flanks 18 and 20 and flanks 22 and 24 extending substantially normally to the length of longitudinal axis of the tubing. The crest 26, 28 of one thread substantially lies respectively at the root 30, 32 of the other assembly and *vice versa*, as is conventional in all screw-thread forms. It is not practical to shape the crest 26, 28 of one thread to make a tight fit with the root 30, 32 of the other and hence helical gaps 34, 36 are formed. The flanks 18, 20 and 22, 24 are a tight fit and will not normally provide any leakage path.

In buttress thread forms whenever complete sealing is necessary, such as that shown, at least one metal-to-metal annular sealing zone 40 is incorporated, the dimensions being such that when the threads are fully engaged and tightened, the sealing zones will be in compressive contact so that no leakage can occur.

As will be seen in the drawing, the seal surfaces, extending generally axially 42, 44 lie at one end of one part 16 and inwardly of the end of the other part 14. The surfaces of sealing zone 40 are mutually compressed when the threads are fully torqued with shoulder surfaces 46, 48 in tight contact. To effect the required degree of compression in the surfaces of the sealing zone 40, they are so disposed relatively to one another that contact is made slightly in advance of the angular location at which shoulders 46, 48 abut so that when the shoulders abut fully the sealing surfaces are slightly deformed under the compression loading. For the sake of clearly illustrating the surfaces, in particular the surfaces 42, 44, 46 and 48, they have been shown spaced apart, but when fully torqued the opposed abutment surfaces 46, 48 will be in tight contact and each pair would be shown only as a single line. The surfaces 42, 44 are not in contact even when the parts 14, 16 are subjected to full torque.

The screw threads illustrated in Fig.2 are again formed on two opposed parts 50, 52 having respective crests 54, 56 and troughs 58, 60 which are defined by the helical threads of trapezoidal form. In this conventional thread form however, in some cases the last turn 62 of the thread of part 50 is generally of triangular section while the corresponding turn of the part 52 remains trapezoidal. This results in a substantially annular clearance 64 so that contact does not take place at the helical lines 66 and 68 when the parts 50, 52 are fully torqued. An end portion 70 of the part 50 has an external surface 72 (i.e. facing away from the longitudinal axis of the part) which is generally annular but convex as viewed in cross-section. This surface 72 co-operates with a corresponding annular internal surface 74 which is concave as viewed in cross-section but the curvature differs so that, as is apparent from Fig. 2 contact takes place between surfaces 72 and 74 only over a relatively small proportion of the areas of each surface. Actual deformation at the annular contact surface zone 76 takes place so that, in theory the seal is perfect. Surfaces 78, 80 which correspond to surfaces 46, 48 of Fig. 1, are in abutment when fully torqued, but have been illustrated as spaced from one another to enable the individual surfaces to be seen.

However, it is conventional practice liberally to coat the whole of the screw-threads of the types just described with a hydrocarbon-grease-based lubricant and secondary sealant (conventionally termed "dope") containing soft metal particles of various sizes up to about 100 microns and at full toruqe this "dope" congregates in the helical gaps 34, 36 and 64. The "dope" also becomes trapped in the sealing zones 40, 76 and can impair the sealing action by allowing the full torque to be applied prematurely to the surfaces of sealing zones 40, 76 because the shoulders 46, 48 (Fig. 1) 78, 80 (Fig. 2) cannot properly abut. Indeed pipe and coupling manufacturers specify torque correction factors which depend on the particular dope used and if these factors are ignored there is a substantial risk that a seal effective at pressures of the order of 420 kg./sq. cm., and possibly higher, will not be formed. If these factors are ignored, there is also a risk of excessive torques leading to damage to the sealing surfaces.

The absence of such effective seal is generally regarded not to be important particularly in the early life of the well, because the dope in the helical gaps 34, 36, 64 will prevent leakage. In some cases the high temperatures encountered in some wells will reduce the viscosity of the hydrocarbon vehicle and the metallic particles will not alone block the leakage because the spaces between the particles can readily allow the build up of a path for leakage, particularly under high pressures.

Leakages of this kind cannot always be detected before installation because of the presence of the dope, even if a sophisticated test as described in our co-pending application No. 8025902 is employed. The reason for the apparent failure of the test to detect a leak is the dope itself, one of the roles of which is intended to be the permanent prevention of leakage. High temperatures are assumed to be accommodated by the soft metallic particles, but the large size provides a leakage path too readily in the absence of the grease.

It is a known property of molybdenum disulphide that it will bond with a steel surface so that a molecular thickness layer of MbS_2 can be produced. Molybdenum disulphide in an oleaginous vehicle is well known as a lubricant for moving parts and is added to the normal lubricating oil.

The essential feature of the preferred method is that prior to the assembly of two screw-threaded steel (or steel alloy) parts for example of the form illustrated in Fig. 1, or in Fig. 2 a dry film layer of molybdenum disulphide or a colloidal element such as graphite or polytetrafluoroethylene is applied to one of the mating screw threads before assembly, preferably to the female thread, (thread of the box of the coupling). The molybdenum disulphide or other dry film lubricant is carried in a low viscosity carrier, such as trichlorethylene, trichloroethane or one of the fluorchlorohydrocarbons, the latter being particularly useful if the active constituent is to be applied in aerosol form, which leaves a thin layer on the screw thread and in particular on the otherwise metal-to-metal contact parts of the sealing zone 40, 76 and on the thread flanks 18

and 22 (Fig. 1) 55, 57 (Fig. 2). The layer applied to the crest and trough surfaces 30, 36 (Fig. 1) 54, 56, 58, 60 (Fig. 2) is ineffective since the purpose of the layer on the seal surfaces and on the flanks is to prevent galling when the threads are tightened or slackened off. The proportion of molybdenum disulphide in the low viscosity or volatile vehicle will normally amount to no more than 10% by weight, although proportions ranging from ½% to 25% are possible. After the molybdenum disulphide has been sprayed on, it is left to dry for a short period prior to mating the threads. A Ketonic resin is preferably used to give rapid bonding of the film to the screw threads.

Although it is preferred to use a compound such as molybdenum disulphide because of its strong affinity for steel and steel alloys, colloidal graphite, or polytetrafluorethylene-based substances may also be used. Certain of these materials withstand temperatures up to at least 400°C. The molybdenum disulphide or other dry film lubricant forms one protection agent of the method.

The molybdenum disulphide or other dry lubricant is preferably applied as a mixture of the dry lubricant, a resin and the low viscosity carrier. Any resin can be used which will adhere as a dry film to a metal surface, however the resin used is preferably Ketonic resin.

The use of a dry film lubricant alone has the disadvantage that as the tightening torque applied to the coupling brings the threads to a small angular distance from abutment of the shoulders 46, 48 (Fig. 1) 78, 80 (Fig. 2) the applied torque rises steeply because of the absence of hydrodynamic (pressure) lubrication as with conventional dopes. Hydrodynamic pressure will build up wherever there is contact. In general, the torque necessary over the final turn is higher than that required for conventional API (American Petroleum Institute) modified pipe dope.

In order to reduce the torque, particularly as it approaches the maximum value, the male screw-thread (the pin thread) is coated with a fluid modifier which, is not a solvent for the dry film lubricant applied to the female thread. A suitable fluid modifier is a low viscosity aqueous material incorporating a small quantity of a wetting agent/surfactant (0.1% to 1%) plus a corrosion inhibitor. A typical wetting agent/surfactant is WS 50 formulated by BOC-Nowsco Ltd. This is a non-ionic formulation incorporating ethylene oxide groups and methanol. The wetting agent may be glycerine. The liquid modifier lubricant can be considered as a second protection agent. If the male thread is coated with dry film lubricant, then the "wet" lubricant will, of course, be applied to the female thread.

A typical formulation for the wet lubricant is 50% water, 47.9% methanol, 2.0% corrosion inhibitor (for example "CRODIN"—Registered Trade Mark) and 0.1% friction reducer (for example FC 760) which also acts to lower the surface tension and so improve wetability.

As an alternative to the water-based "wet" liquid lubricant, silicones can be used, including fluorinated silicones. A generalized requirement for the "wet" lubricant is that it should have good wetability, low viscosity and capable of retaining these properties at low temperatures, say down to −40°C.

In order to ensure that the screw-thread protection is effective for the whole of any given screw thread, it is desirable that the thread should initially be cleaned thoroughly. One way of effecting this is the application of an aerosol of air and grease solvent sprayed on to the thread in question and immediately thereafter the dry lubricant is sprayed on the box thread and allowed to dry fully before the "wet" lubricant is applied to the pin thread. Evaporation of the grease solvent may be encouraged by an air blast.

It is conventional that slackening torques can be of the order of 40% higher than tightening torques. The protection agents used in methods in accordance with the invention do not substantially affect this characteristic irrespective of whether the dry protection agent is present during the slackening operation or both agents are present. This higher slackening or break-out torque is desirable since otherwise there is some risk that the coupling will slacken (back-off) inadvertently.

The following are test results comparing various parameters of the protection agents in accordance with the invention and of a conventional API modified dope.

	DRY FILM PROTECTION AGENT IN ACCORDANCE WITH THE INVENTION	API MODIFIED DOPE
TORQUE MULTIPLIER	1.1 (with liquid torque modifier)	1.0
TYPICAL BREAKOUT TORQUE (AS PERCENTAGE OF MAKE-UP)	125%	128%
COEFFICIENT OF FRICTION (1 KN LOAD AMSLER TEST)	0.04 (Dry film only)	0.12
CURING TIME—TOUCH DRY (20°)	2 MINS	NOT APPLICABLE
APPLICATION TEMPERATURE RANGE OF PIPE	+ 5° to 40C	− 20°C to 40°C
MAXIMUM OPERATING TEMPERATURE	350°	148°C
OXIDATION ABOVE	400°C	177°C
MELTING POINT	1800°C	LOW
SPECIFIC GRAVITY	1.4 TO 1.3	1.82
FILM DENSITY	0.6MG/CC	8.8MG/CC
TYPICAL COAT THICKNESS	0.0005	0.004
HARDNESS (MOH'S SCALE)	1 to 15	NOT APPLICABLE
FALEX BREAKDOWN LOAD	2500 LB.	750 LB
TIMKEN TEST LIFE AT 420 Kg/Sq.cm.	60 mins.	Less than 15 minutes
RESPONSE TO 30 STANDARD CUBIC FEET PER YEAR LEAK THROUGH 41/2" COLLAR (11.43 cm)	30 secs.	None
APPEARANCE	Matt grey	Dark grey
APPLICATION	Spray	Brush
COMPOSITION	90% Solvent 10% Active Ingredients	36% Grease 64% Solids Graphite, Lead Zinc, Copper

The figure given above in relation to the torque and multiplier applies to the final make-up torque.

The method hereinbefore described will ensure that any leak detection tests on tubing strings before installation will not be falsified after installation as a result of the reduction of the viscosity of the hydrocarbon grease of conventional coupling sealant dopes. The thin film produced by the dry film thread protection agent will not impair the sealing action of the thread flanks or of the specific sealing zones at the ends of the screw threads. Any leakage at the specific sealing surfaces 42, 44, 76 of the illustrated screw threads will not be masked since the helical path between helical surfaces will be blocked only by the low viscosity aqueous material or the other wet lubricant and any leakage flow through the helical path will merely form a passage through the material. The agents serve to eliminate (or at least reduce the risk) of galling of the threads thus making uncoupling and recoupling possible. The very small particle size—of the order of one micron—eliminates the risk of leakage paths being formed in the sealing zones.

The addition of a liquid modifier protection agent when used with the dry film lubricant serves to reproduce make-up and break-out characteristics (torque) of traditional lubricants/sealants (dope) currently in use.

CLAIMS

1. A method of protecting mating screw threads and associated sealing surfaces at least under tightening torques, the method comprising the steps of applying a dry film lubricant to one screw thread and the associated sealing surface, applying a liquid lubricant to the other

screw thread and the associated sealing surfaces, mating the screw threads and tightening to the required torque value, the liquid lubricant having substantially no solvent action on the dry film lubricant, the method serving both to protect the mating threads and associated sealing surfaces and to avoid the masking of any leakage path between the threads.

2. A method of protecting the screw threads and associated sealing surfaces of mating screw-threaded members at least under tightening torques, the method comprising the steps of spraying a dry film lubricant in a volatile carrier on to a female thread and associated sealing surface, allowing the carrier to evaporate, applying a liquid lubricant to the male thread and associated sealing surface, immediately mating the threads and tightening to the required torque value, the liquid lubricant having good wetability and low viscosity, the method serving to protect the threads and sealing surfaces against mutual damage and to prevent masking of any leakage path under test conditions.

3. A method according to claim 1 or claim 2 wherein the dry film lubricant includes molybdenum disulphide.

4. A method according to claim 1 or claim 2 wherein the dry film lubricant is colloidal graphite.

5. A method according to claim 1 or claim 2 wherein the dry film lubricant is selected from one of the polytetrafluorethylenes.

6. A method according to any one of the preceding claims wherein the dry film lubricant is applied to the screw thread in a low viscosity carrier.

7. A method according to claim 6, wherein the carrier is trichlorethylene, trichlorethane, or a fluorchlorhydrocarbon.

8. A method according to claim 6 or claim 7 wherein the low viscosity carrier includes a ketonic resin.

9. A method according to claim 6, 7 or 8 wherein the proportion of dry film lubricant in the carrier is in the range $\frac{1}{2}$% to 25%.

10. A method according to any one of the preceding claims wherein the liquid lubricant is aqueous and includes a quantity of a wetting agent/surfactant.

11. A method according to claim 10 wherein the wetting agent/surfactant is a non-ionic formulation incorporating ethylene oxide groups and methanol.

12. A method according to any one of the preceding claims, wherein the screw threads each have an adjoining said sealing surface which, when fully torqued are in sealing contact.

13. A method according to any one of claims 1 and 3 to 12 except when appendant to claim 2 wherein the dry film lubricant is applied to the female thread and adjacent sealing surface.

14. A method of protecting the screw threads and associated sealing surfaces of mating screw-threaded members, the method comprising the steps of spraying molybdenum disulphide in a volatile carrier on to a female thread and the associated sealing surface, allowing the carrier to evaporate thus leaving a coating of molybdenum disulphide on the thread and sealing surface, applying an aqueous liquid lubricant to the male thread and associated sealing surface, the liquid lubricant containing water, methanol and a corrosion inhibitor, and immediately mating the threads and tightening to a torque value which produces a seal between the sealing surfaces.

15. A method protecting mating screw threads substantially as hereinbefore described with reference to the accompanying drawing.

Printed in the United Kingdom for Her Majesty's Stationery Office, Dd 8818935, 1984, 4235.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.